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SPECIAL ISSUE ON RECENT RESEARCH CHALLENGES IN BIO-MEDICAL APPLICATIONS

Ergonomic Analysis of Human Lumbar Spine Image Using Canny Edge Detection Algorithm

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The largest segment of the movable part is the lumbar vertebrae that are composed of vertebral column, starting at the top from L1 to L5. The spinal column, or the backbone, is primarily made up of vertebrae discs, and the spinal cord. The 24 articulating vertebrae, and nine fused vertebrae in the sacrum and the coccyx will combine to form the vertebral column. The inter vertebral discs are used to separate the vertebral columns that are situated in the dorsal aspect of the torso. The commonly specified word spine or simply backbone is said to be the house that protects the spinal cord in its spinal canal. Signals are transmitted and received through the spinal cord which acts as a communication conduit for the brains. It is otherwise known as vertebral column. It consists of 24 separate bony vertebrae together with 5 fused vertebrae. The disc strength and flexibility required to bear the load of the lumbar spine, is provided by means of the unique interaction between the solid and fluid components. The Segmentation of Spine Image between lumbar spines and CT scan spine disc images are done using Bilateral Filter and Canny Edge Detection Algorithm. It is clear that the canny edge detection provides better result than that of other edge detection algorithm. The most difficult problem is to find the correct boundary in a noisy image of spine disc. A standard result can be used to find out absolute edges from noisy images. An optimal solution is produced by the canny edge detection algorithm as that of the original solution. It works efficiently for all kinds of noisy images

Key words: Spine Disc image, Finite Element Modelling, Bilateral Filter, Canny Edge Detection, CT scan, Magnitude and Edge Length.

The approximate solutions to boundary value problem for differential equations can be found using the finite method which is a numerical technique .The protection for spinal cord is provided by composite structure. Most industrial plants carry out Manual material handling operations. A stable solution along with the minimization of error is produced through the variational operations. Approximately a larger circle is implemented with the connection of many tiny straight lines. A more complex equation over a larger domain connects many simple element equations over many small sub domains, named finite elements is encompassed by FEM. Each behavior task poses unique trouble on the employee. Implementation and maintenance of proper policies and procedures can help employees to perform these tasks safely and easily in their workplaces. The part that plays a vital role in research is the lumbar region, which is a part of the spine. In literature the relationship between anatomy lumbar regions, the lumbar spine, and the back pain are put together. The FEM modeling of

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the spine is analyzed under the aircraft ejection as well as for aircraft injuries[1,2]. The explanation along with its uses in the field of orthopedics for the lumbar region[3] is analyzed by finite element analysis. The evaluation and management of occupational low back disorders and back pains were studied. The illustration of the movement of human by motor control and biomechanics[4,5] are specified with various aspects. Such similar investigations are made on the spine disk and are reported. A vertebrae and a disc are the two parts of the motion segment of the spine up to date[6,7,8] . Edge detection technology is the fundamental tool used to explicate proper information from the images. This provides the outline of an image and boundaries[9]. The removal of noises in the images and enhancement of the appearance is made by this tool. For pre-processing the boundary detection of the CT-scanned disk image of the spine Canny Edge detection algorithm has been proposed which is based on the magnitude and Edge length algorithm. It is still difficult to detect the correct boundary in a noisy image. A better result is produced by the canny edge detection algorithm that is used to detect the boundaries of spine disc image from the noisy CT scanned image. The Fig.1 shows a 2D model of spine disc image and the Fig.2 gives a clear view of the same in 3D model. The vertebral body of each lumbar vertebra is large, wider from side to side than from front to back, and a little thicker in front than in back. It is flattened or slightly concave above and below, concave behind, and deeply constricted in front and at the sides. The Fig.3 illustrates the various spine disc disorders. And Fig. 4 represents the spine image.

Fig.1. Spine Disc 2D Model

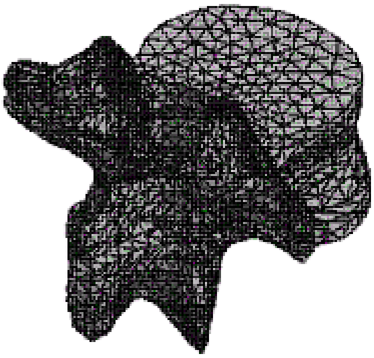

Fig. 2. Spine Disc 3D Model

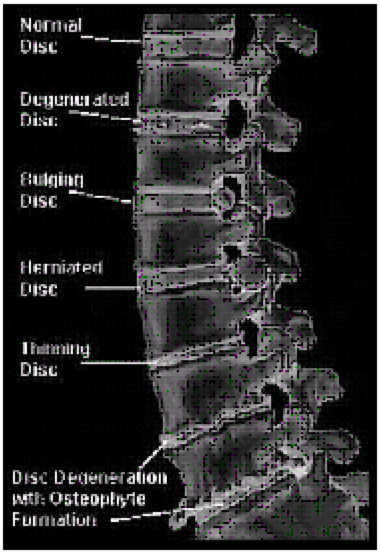

Fig. 3. Spine Disc disorders

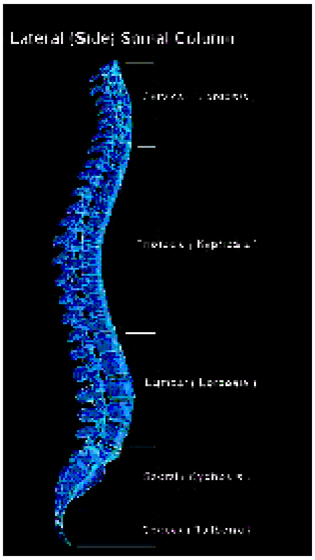

Fig. 4. The Spine Image

Table.1 gives the behaviors and properties of the spine. For exact results FEA consists of a computer model of a material or design that has to be stressed and analyzed. New manufactured goods, design, and existing product refinement makes use of this. Prior to manufacturing or construction of a company is able to verify a proposed design can perform to the client's specifications. For a new service condition, the modification of existing product or structure is utilized to qualify the product or structure. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition

Various edge detection techniques applied for lumber spine disc image

For comparison there are three most frequently used edge detection methods. They are (1).Bilateral Filter (2).Canny Edge detection. The detail of each method as follows,

Proposed workflow sequence

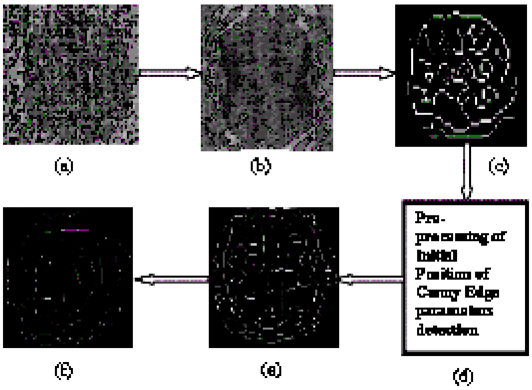

Fig. 5. (a).CT scan Noisy Spine Disc image; (b). Average Magnitude Image; (c). Density of the Edge Length; (d). Processing Sequence; (e). Initial Position map; (f). Final Thresholding of edge map

Bilateral Filter

A non-linear, edge-preserving and noise-reducing smoothing filter for images is a bilateral filter. The weighted average of intensity values from nearby pixels replaces the intensity value at each pixel in an image. This weight can be based on a Gaussian distribution. This weight depends on both Euclidean distances of pixels, and also on the radiometric differences (e.g. range differences, such as color intensity, depth distance, etc.). Systematic looping through each pixel preserves sharp edges and adjusts weight to the adjacent pixels accordingly.

The bilateral filter is defined as

$$I^{\text{filtered}}(x) = \frac{1}{W_p}\sum_{x_i\in\Omega} I(x_i) f_r(\|I(x_i)-I(x)\|) g_s(\|x_i - x\|),$$

where the normalization term

$$W_p = \sum_{x_i\in\Omega} f_r(\|I(x_i)-I(x)\|) g_s(\|x_i - x\|)$$

ensures that the filter preserves image energy and

- I^{filtered} is the filtered image;
- I is the original input image to be filtered;
- x are the coordinates of the current pixel to be filtered;
- Ω is the window centered in ;
- f_r is the range kernel for smoothing differences in intensities.
- g_x is the spatial kernel for smoothing differences in coordinates

The basic idea underlying bilateral filtering is to do in the range of an image what traditional filters do in its domain. Two pixels can be close to one another, that is, occupy nearby spatial location, or they can be similar to one another, that is, have nearby values, possibly in a perceptually meaningful fashion.

Consider a shift-invariant low-pass domain filter applied to an image

$$\mathbf{h}(\mathbf{x}) = k_d^{-1}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\mathbf{f}(\xi)c(\xi - \mathbf{x})d\xi$$

The bold font for f and h emphasizes the fact that both input and output images may be multi-band. In order to preserve the DC component, it must be

$$k_d = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} c(\xi)d\xi$$

Table 1. Spine Properties

Material	Young's Modules (Mpa)	Cross Section Area (mm^2)
Anterior Longitudinal	7.8	63.7
Posterior Longitudinal	10	20.0
Ligamentum Flavum	15	40.0
Transverse	10	3.60
Capsular	705	60.0
Interspinus	10	40.0
Superspinus	8	30.0
Iliolumbar	10	26.4

Range filtering is similarly defined

$$\mathbf{h}(\mathbf{x}) = k_r^{-1}(\mathbf{x})\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\mathbf{f}(\xi)s(\mathbf{f}(\xi)-\mathbf{f}(\mathbf{x}))d\xi$$

In this case, the kernel measures the photometric similarity between pixels. The normalization constant in this case is

$$k_r(\mathbf{x}) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}s(\mathbf{f}(\xi)-\mathbf{f}(\mathbf{x}))d\xi$$

The spatial distribution of image intensities plays no role in range filtering taken by itself. Combining intensities from the entire image, however, makes little sense, since the distribution of image values far away from x ought not to affect the final value at x. In addition, one can show that range filtering without domain filtering merely changes the color map of an image, and is therefore of little use. The appropriate solution is to combine domain and range filtering, thereby enforcing both geometric and photometric locality.

Combined filtering can be described as follows:

$$\mathbf{h}(\mathbf{x}) = k^{-1}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\mathbf{f}(\xi)c(\xi-\mathbf{x})s(\mathbf{f}(\xi)-\mathbf{f}(\mathbf{x}))d\xi$$

with the normalization

$$k(\mathbf{x}) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}c(\xi-\mathbf{x})s(\mathbf{f}(\xi)-\mathbf{f}(\mathbf{x}))d\xi$$

Combined domain and range filtering will be denoted as bilateral filtering. It replaces the pixel value at x with an average of similar and nearby pixel values. In smooth regions, pixel values in a small neighbourhood are similar to each other, and the bilateral filter acts essentially as a standard domain filter, averaging away the small, weakly correlated differences between pixel values caused by noise. Consider now a sharp boundary between a dark and a bright region

The canny edge detection

The Canny algorithm can be used an optimal edge detector based on a set of criteria which include finding the most edges by minimizing the error rate, marking edges as closely as possible to the actual edges to maximize localization, and marking edges[10,11] only once when a single edge exists for minimal response. According to Canny,

Fig. 6. (a).CT scan Noisy Spine Disc image; (b). Average Magnitude Image; (c). Density of the Edge Length; (d). Final Thresholding of edge map

Pre-processing of initial position of edge parameters detection

Step 1: Calculate the average magnitude

$$\mathbf{M(1,2)} = \frac{1}{M}\sum_{(1,2)}^{n}\sqrt{\mathbf{Mx(1,2)^2 + My(1,2)^2}}$$

The optimal filter that meets all three criteria above can be efficiently approximated using the first derivative of a Gaussian function.

$$\mathbf{GF(i,j)} = \frac{1}{2\pi\sigma^2}\, e^{\frac{i^2+j^2}{2\pi\sigma^2}}$$

Step 2: Calculate the density of the edge length, The density of the edge length is calculated from

$$\mathbf{L(1,2)} = \frac{C(1,2)}{\max C(1,2)}$$

Table 2. Comparison between Bilateral Filter and Canny Edge Detection Algorithm for CT Scan Lumbar Spine Disc Image.

S. No	Image illustration	Medical Standard Value (%)	Bilateral Filter segmentation (%)	Canny Edge Segmentation (%)	Error Difference in Bilateral Filter segmentation(%)	Error Difference in Canny edge segmentation (%)
1	Ct Scan Noisy Spine Disc Image	8.51	8.56	8.52	+0.05	+0.01
2	Average Magnitude Image	7.73	7.78	7.76	+0.05	+0.03
3	Density of Edge Length Image	7.00	7.07	7.01	+0.07	+ 0.01
4	Filtered CT Scan Image	6.44	6.35	6.43	-0.09	- 0.01
5	Initial Position Map	5.90	5.97	5.92	+0.07	+0.02
6	Fine Edge Filtered Image	5.07	5.15	5.11	+0.08	+0.04

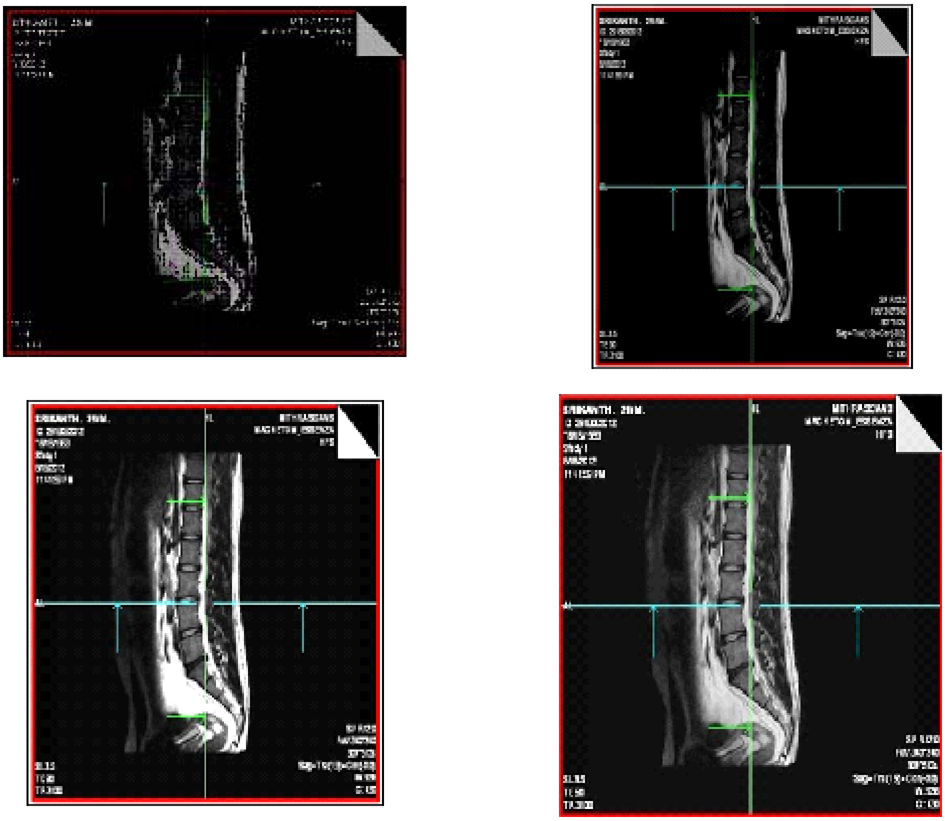

Fig.7. (a).CT scan Noisy Spine Disc image; (b). Average Magnitude Image; (c). Density of the Edge Length; (d). Final Thresholding of edge map.

Where C(i,j) is the number of connected pixels at each position of pixel.

Step 3: Calculate the Initial position of map from summation of density of edge Length and average magnitude.

$$P(1,2) = \frac{1}{2(M(1,2) + L(1,2))}$$

Step 4: Calculate the thresholding of the initial position map.

If $P(1,2) > T_{max}$

Then P(1, 2) is the initial position of the edge following. And then we obtained the initial position by setting T_{max} to 92% of the maximum value.

RESULTS AND DISCUSSION

To further evaluate the efficiency of the proposed method in addition to the visual inspection, the proposed boundary detection method numerically using the Hausdorff distance and the probability of error in image segmentation. Where *P* (*O*) and *P* (*B*) are probabilities of objects and background in images. The objects surrounded by the contours obtained using the five snake models and the proposed method are compared with that manually drawn by skilled doctors from the Medical Hospital. From the above Table.2 shows the average result of probability of Error in Image segmentation of median filter and canny edge detection algorithm were compared with standard Medical values and also predicts the error difference. Showing the results it shows the Error difference value is very minimal and also negligible in median filter. So the Canny edge detection algorithm produced nearer to the standard value. Fig.8 shows the comparative analysis of Bilateral filter and Medical standard value. Fig.9 Shows the comparative analysis Canny edge detection and the Medical standard value which is collected from the standard Hospital.

CONCLUSION

In this paper, the comparative analysis of various edge detection algorithms like Bilateral Filter and canny edge detection algorithm out of which canny edge detection algorithm produced better result for noisy spine disc image. So based on the result the proposed technique for boundary detection is applied it to spine disc image. Our edge following technique incorporates a vector image model and the edge map information. The proposed technique was applied to detect the object boundaries of noisy CT scan spine disc image where the well-defined edges were encountered. The opinions of the skilled doctors were used as the ground truths of interesting object of spine disc. Besides the visual inspection, the canny edge detection method was verified and evaluated using the probability of error. The results of detecting the object boundaries in noisy images show that the canny technique is very close to the standard value which was given by eminent doctors. We have successfully applied the edge following technique to detect the object boundaries of spine disc image. The proposed method can be applied not only for medical imaging, but can also be applied to any image processing problems.

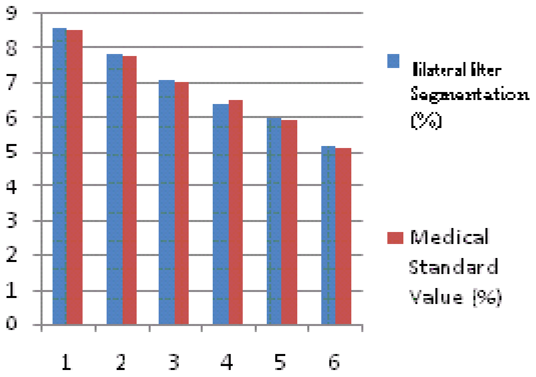

Fig. 8. Comparative Analysis Graph for Bilateral Filter Value and Medical Standard value

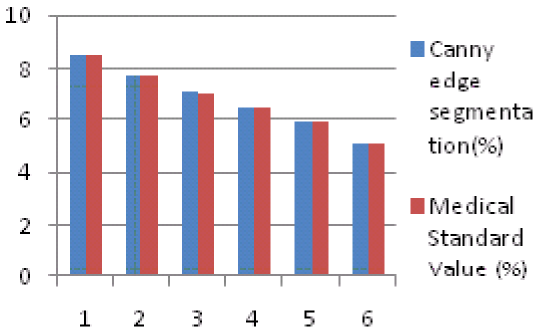

Fig. 9. Comparative Analysis Graph for Canny Edge Detection value and Medical Standard value

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